10.5005/jp-journals-10002-1240

CASE REPORT

Chromaffin-cell Tumors in Pregnancy: A Case Series and Systematic Review

[1]Maximilien Rappaport, [2]Paul Skierczynski, [3]Lauren Dungy-Poythress, [4]Tara Benjamin, [5]Brian D Saunders, [6]Andrew A Wagner, [7]Benjamin C James

ABSTRACT

Aim: We describe three chromaffin-cell tumors managed during pregnancy as well as systematically review case reports published from 2014 to 2018. Chromaffin-cell tumors are rare catecholamine-producing tumors that can arise from the adrenal medulla, where they are referred to as pheochromocytomas, or from extra-adrenal chromaffin tissue, referred to as paragangliomas. The incidence of chromaffin-cell tumors identified during pregnancy is extremely rare, with an incidence of 0.32 cases per 100,000 pregnancy years.

Cases: We describe diagnosis and management during pregnancy of a 25-year-old with a 7.3 cm right pheochromocytoma, a 23-year-old with metastatic paraganglioma and SDHB mutation, and a 28-year-old with MEN2A and a left pheochromocytoma. We performed a systematic review of cases utilizing MEDLINE, EMBASE and Google Scholar with the terms (pheochromocytoma or paraganglioma) and (pregnancy or pregnant) within the timeframe 2014 through 2018 (searched on April 9th, 2018). We found that emergency cesarean section delivery ($p < 0.05$), maternal heart failure or pulmonary edema ($p<0.05$) and fetal or neonatal death ($p < 0.05$) were more common in women with a late or postpartum diagnosis of a chromaffin-cell tumor compared to women with diagnosis during or before pregnancy.

Conclusion: Chromaffin-cell tumors are rare during pregnancy. However, morbidity is severe and requires an early diagnosis for the best possible outcomes. Hypertension during pregnancy is the most common presenting symptom of these catecholamine-producing tumors. Severe hypertension, labile hypertension or hypertension before 20 weeks, without proteinuria or lower extremity edema, should raise suspicion for a chromaffin-cell tumor. Management should consist of an experienced multidisciplinary team at a tertiary referral hospital to ensure the best outcomes.

Keywords: Adrenal tumor, Maternal hypertension, Paragangliomas, Pheochromocytoma, Pregnancy, Pregnant.

How to cite this article: Rappaport M, Skierczynski P, Dungy-Poythress L, Benjamin T, Saunders BD, Wagner AA, James BC. Chromaffin-cell Tumors in Pregnancy: A Case Series and Systematic Review. World J Endoc Surg 2018;10(3):163-169.

Source of support: Nil

Conflict of interest: None

[1]Fellow, [2-6]Associate Professor, [7]Assistant Professor

[1,2]Department of Medicine, Indiana University School of Medicine, Indianapolis, Indiana, United States

[3,4]Department of Obstetrics and Gynecology, Indiana University School of Medicine, Indianapolis, Indiana, United States

[5]Department of Surgery, Penn State Hershey Medical Center, Penn State College of Medicine, Hershey, Pennsylvania, United States

[6,7]Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts, United States

Corresponding Author: Benjamin C James, Assistant Professor, Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts, United States, e-mail: bjames1@bidmc.harvard.edu

INTRODUCTION

Chromaffin-cell tumors are tumors that can synthesize, store, and secrete catecholamines. Chromaffin-cell tumors can arise from the adrenal medulla, where they are referred to as pheochromocytomas, or from extra-adrenal chromaffin tissue, referred to as paragangliomas. The incidence of chromaffin-cell tumors identified during pregnancy is extremely rare, with an incidence of 0.32 cases per 100,000 pregnancy years compared with 0.57 cases per 100,000 person-years in the general population.[1-3] Differentiating these tumors from more common causes of hypertension during pregnancy such as pre-eclampsia is of critical importance due to increased maternal morbidity and mortality as well as fetal demise when diagnosis is made late in pregnancy or postpartum.[4] Management of chromaffin-cell tumors during pregnancy is complicated by the normal physiologic changes during pregnancy such as increased intra-abdominal pressure, fetal movement, uterine contractions as well as labor and delivery.[5] Herein, we describe three cases of chromaffin-cell tumors diagnosed during pregnancy at our institution. We also conducted an updated review of the literature.

CASE SERIES

Case 1

A 25-year-old G3P0202 at 27 weeks gestation was admitted to an outside hospital due to elevated home blood pressures and headaches. On admission, her blood pressure was 152/96 mm Hg with a heart rate of 68 to 133 bpm. Further evaluation revealed elevated liver enzymes with an alanine aminotransferase of 151 U/L (6 to 65

U/L) and aspartate aminotransferase of 77 U/L (15 to 37 U/L). Platelet count and creatinine were normal and there was no proteinuria or lower extremity edema. An abdominal ultrasound performed denoted an incidental right-sided adrenal mass. Further evaluation with MRI revealed a 7.3 x 6.2 x 3.9 cm right adrenal mass with internal cystic degeneration and displacement of the IVC (Fig. 1). She was transferred to a tertiary care center for further management.

Expanded clinical history revealed a several years history of hypertension as well as hypertension during prior pregnancies. She reported intermittent spells of diaphoresis, palpitations, headaches, dyspnea, and anxiety. Her first pregnancy was complicated by placental abruption at 28 weeks gestation requiring emergent cesarean section. Her postoperative course during that first pregnancy was complicated by severe hypertension up to 230/136 mm Hg and pulmonary edema requiring mechanical ventilation. She was eventually discharged in stable condition. Her second pregnancy was similarly complicated by preterm labor and a diagnosis of preeclampsia.

Upon transfer to our institution, she had severe range blood pressures as high as 202/114 mm Hg with heart rate values up to 160 bpm. Biochemical evaluation included elevated serum epinephrine 82 pg/mL (<50 pg/mL), norepinephrine 15,048 pg/mL (112 to 658 pg/mL), dopamine 297 pg/mL (<30 pg/mL), metanephrine 101 pg/mL (<57 pg/mL), and normetanephrine 4,511 pg/mL (< 148 pg/mL). Twenty-four hour urine studies demonstrated metanephrines 233 mcg/24 hour (25 to 222 mcg/24h), normetanephrine 9,393 mcg/24 hour (40 to 412 mcg/24h), and protein 186 mg/24 hour (<300 mg/24h).

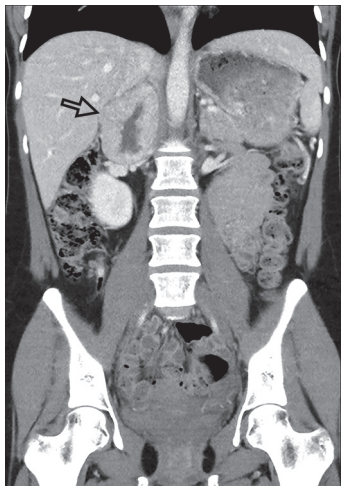

Fig. 1: CT w/ contrast postpartum: heterogenous, peripherally enhancing, centrally necrotic right adrenal mass measuring 7.8 x 6.0 x 5.5 cm, located between the infrahepatic inferior vena cava and suprarenal abdominal aorta

Therapy for a catecholamine-secreting tumor was initiated with a phentolamine infusion at 8 mg/hr co-administered with phenoxybenzamine 10 mg TID. Phentolamine was then stopped and blood pressures normalized on phenoxybenzamine 10 mg PO BID and labetalol 100 mg PO BID with orthostatic hypotension not less than 90/50 mm Hg allowed. At 33 weeks premature rupture of membranes occurred and cesarean delivery was performed. Intraoperatively the apex arterial blood pressure recorded was 175/115 mm Hg with postoperative blood pressure 144/86 mm Hg. At birth, the infant weighed 2090 grams, had APGAR scores of 1/3/5/6, and was in NICU 3 weeks. No other maternal or fetal complications occurred.

Three months postpartum, the patient underwent open right adrenalectomy. Intraoperative arterial blood pressure peaked at 208/120 mm Hg. The surgical pathologic evaluation demonstrated a pheochromocytoma with focal invasion into but not through the capsule, no vascular invasion, and <4 mitotic figures/10 high power fields. Surgical margins were free of tumor. The patient was discharged home post-operative day 5 in stable condition.

Case 2

A 23-year-old G1P0 at 37 weeks gestation presented with a known medical history of metastatic paraganglioma with heterozygous SDHB mutation, p.C253Y. She was diagnosed at age 10 and underwent surgical resection of a left adrenal mass, which demonstrated positive chromogranin and synaptophysin on histology. At age 21 during an appendectomy, a retroperitoneal mass and multiple metastatic lesions were identified, as were a 2.3 cm left adrenal mass, a 6 cm aortocaval mass, and several bony lesions involving right iliac bone, left ischial ramus, multiple thoracic and lumbar vertebrae (Fig. 2). She underwent autologous stem cell apheresis and 530 mCi I-131 MIGB therapy.

She was admitted for observation at an outside hospital at 37 weeks gestation for intermittent hypertension at home. She reported home blood pressures of 215/125 mm Hg with headaches. During observation, her maximum blood pressure was 230/107 mm Hg. Biochemical evaluation revealed: 24-hour urine normetanephrine elevated at 4789 mcg/24 hour (40 to 412 mcg/24h), metanephrine 63 mcg/24 hour (25 to 222 mcg/24h), total protein 223.50 mg/24 hour (< 300 mg/24h). Intravenous phentolamine 5 mg Q 4 hours was initiated. Once blood pressure control was achieved, she was transitioned from phentolamine to phenoxybenzamine 10 mg PO BID and labetalol 100 mg PO BID.

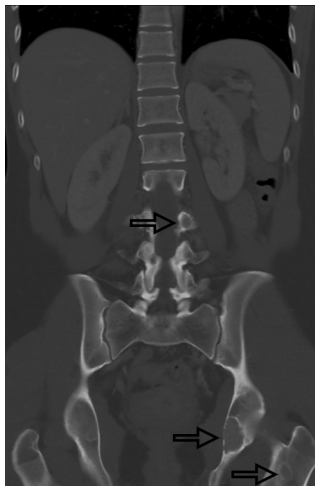

Fig. 2: CT abdomen/pelvis w/ IV contrast prior to pregnancy. There are multiple lytic bone lesions; a lesion within the left transverse process of the third lumbar vertebral body, a large lytic lesion within the left ischium with lucency extending through medial cortex and a smaller sclerotic lesion seen within the left femoral intertrochanteric crest

She underwent a scheduled cesarean section at 38 weeks gestation of a 3,650g infant with APGARs 6/7/8. Her highest recorded intraoperative arterial blood pressure was 165/100 mm Hg. Her postoperative course was complicated by a seizure without hemodynamic changes that was ultimately attributed to calvarial metastases stretching the dura. Both the patient and infant were eventually discharged in stable condition.

Case 3

A 28-year-old female G3P1011 was diagnosed with a left pheochromocytoma at 32 weeks gestation. Her past medical history included a diagnosis of MEN2A, status post right total adrenalectomy for a pheochromocytoma, medullary thyroid carcinoma status post total thyroidectomy and primary hyperparathyroidism status post subtotal parathyroidectomy.

On biochemical evaluation at 25 weeks gestation, serum normetanephrine was 1.6 nmol/L (<0.90 nmol/L), metanephrine 0.75 nmol/L (<0.50 nmol/L), 24 hour urine metanephrine 718 mcg/24 hour (30 to 180 mcg/24h), and normetanephrine 833 mcg/24 hour (103 to 390 mcg/24h). Abdominal MRI was performed and demonstrated a T2 hyperintense 1.9 cm left adrenal lesion, with no signal loss on out of phase imaging suggestive of a pheochromocytoma (Fig. 3).

She was treated with 1 mg daily doxazosin. She underwent scheduled cesarean delivery at 39 weeks during which maximum arterial blood pressure was 165/95 mm Hg. No maternal or fetal complications occurred. At birth, the infant was 3,380 grams with APGARs 9/9.

Four months postpartum, she underwent an uneventful robotic left partial adrenalectomy. Maximum arterial blood pressure intraoperatively was 195/105 mm Hg. She recovered without complication.

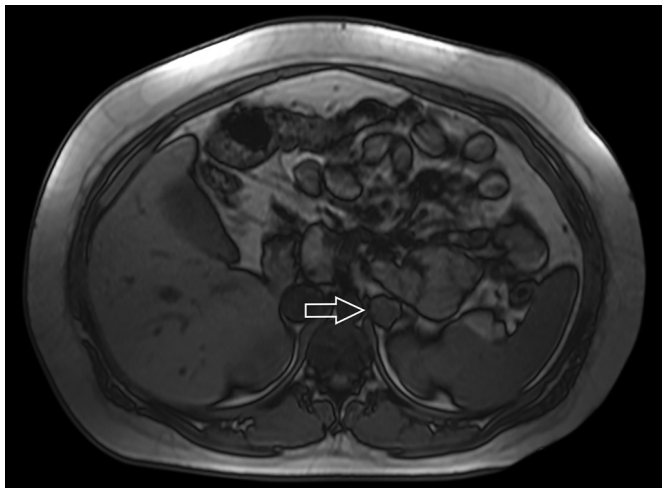

Fig. 3: MRI T1 out of phase image w/o contrast obtained while patient was 33 weeks pregnant. A 1.9 x 1.9 cm lesion within the left adrenal gland that does not demonstrate significant signal loss on out of phase imaging

Methods

An updated review of full-text English language cases published since 2014 was performed systematically. Search engines included MEDLINE, EMBASE and Google Scholar with the terms (pheochromocytoma or paraganglioma) and (pregnancy or pregnant) within the timeframe 2014 through 2018 (searched on April 9th, 2018). After excluding duplicate articles and abstract only articles, published data were aggregated. Cases were included if the diagnosis of a chromaffin-cell tumor was clearly described, as well as the timing of diagnosis, presenting symptoms, the location of the tumor, delivery method, medical or surgical complications, maternal and neonatal outcomes. Cases were excluded if they were written in a language other than English or missing two or more of the inclusion criteria. Composite outcome data were analyzed and reported. Two subgroups were identified; patients with chromaffin-cell tumor diagnosed during the antenatal period and patients with a chromaffin-cell tumor diagnosed postpartum, after acute illness leading to an emergency cesarean section, or maternal or fetal death. A two-tailed Fisher's exact test was performed on the two identified subgroups comparing maternal survival, fetal survival, emergency cesarean section and preterm labor. Our hypothesis was that there would be more complications for late or missed diagnosis of the chromaffin-cell tumor during pregnancy.

There were 63 cases identified after exclusion of 40 duplicate records, 35 abstract only records, 9 non-English publications and 80 articles without a clinical case reported (Fig. 4). A total of 40 manuscripts were included

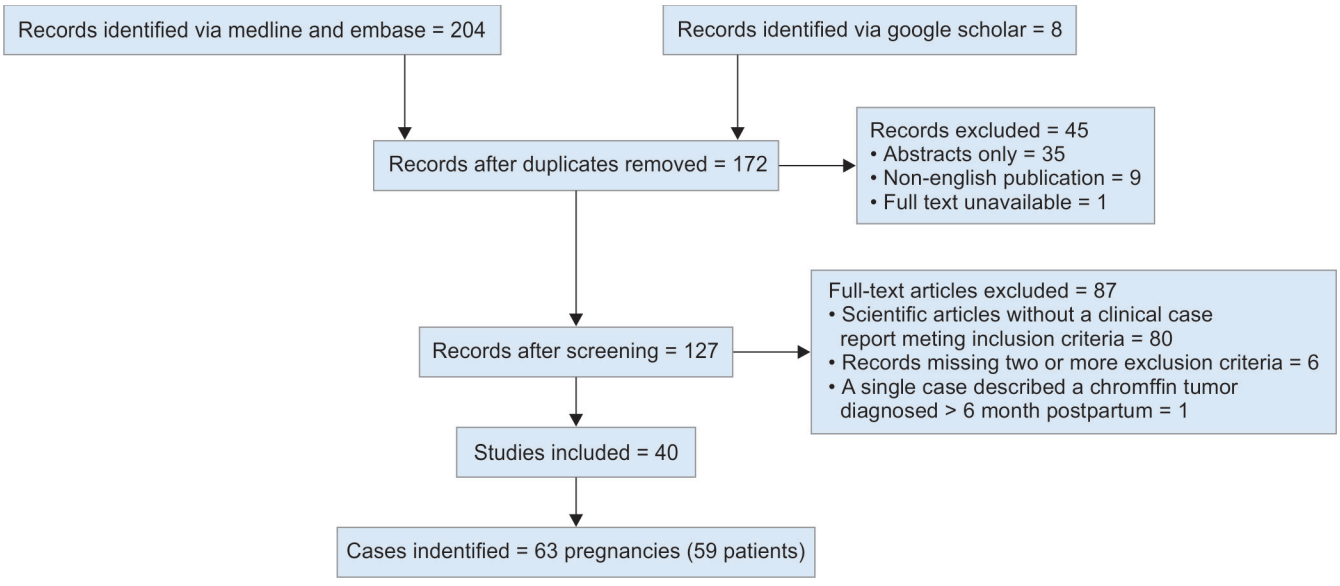

Fig. 4. Systematic review flowsheet

reporting on 59 pregnant women. Data are summarized in Table 1 with outcome data summarized in Table 2 [Complete detailed review of cases is available as a supplementary file S1 (online only)].

RESULTS

The mean age of the women included was 29 years. The most frequently reported presenting symptoms were hypertension, tachycardia or palpitations, abdominal pain/nausea or vomiting, and headache. Forty tumors were diagnosed in the antenatal period, most commonly in the second trimester. Twenty-three tumors were diagnosed postpartum, or due to acute illness leading to an emergency cesarean section, or maternal, fetal or neonatal death.

Each diagnosis of a chromaffin-cell tumor was based on the biochemical investigation, imaging and/or histologic confirmation, in the single reported case of maternal death, an autopsy confirmed the diagnosis. Biochemical investigation performed during pregnancy demonstrated elevated catecholamines in 92% (45/49) cases. Imaging modalities utilized during pregnancy included ultrasound, magnetic resonance imaging, and computed tomography.

The most common diagnosis was unilateral pheochromocytoma 63.5% (40/63), with the remaining cases being paragangliomas 25.4% (16/63) followed by bilateral pheochromocytomas 9.5% (6/63). Genetic mutations were confirmed in 23.8% (15/63), an additional five patients had a family history SDH-B, VHL or RET mutations. The most common genetic mutations were RET proto-oncogene mutation and SDH-B mutation.

Medical treatment consisted of alpha and beta blockade. Phenoxybenzamine was the most frequently cited

Table 1: Details of cases identified 2014 to 2018

	n
Total cases	63
Mean age (years)	29.01
Timing of Diagnosis	
Prenatal	5
1st trimester	7
2nd trimester	17
3rd trimester	11
Due to acute illness leading to emergency cesarean section or after maternal or fetal death	9
During induction of labor	1
Postpartum	13
Presenting Symptoms	
Hypertension	39
Tachycardia or palpitations	20
Abdominal pain/nausea/vomiting	16
Headache	16
Diaphoresis	9
Dizziness/syncope	6
Respiratory distress/dyspnea	5
Hyperglycemia or gestational diabetes	4
Facial paleness or flushing	4
Hypotension	2
Tumor Location	
Unilateral Pheochromocytoma	40
Bilateral Pheochromocytoma	6
Paraganglioma	16
Metastatic Pheochromocytoma	1
Type of Delivery	
Cesarean Section	43
Vaginal	16
n/a	4
Genetic Mutation	
RET	6
Somatic HIF2 Mutation	1
SDHB	6
NF-1	2

Contd...

Contd...

	n
Suspected SDHB based on family history	3
Suspected VHL based on family history	1
Suspected RET based on family history	1
Not available	31
Negative genetic testing	12
Alpha blocker during pregnancy N = 31	
Phenoxybenzamine	14
Doxazosin	9
Prazosin	7
Terazosin	1
Biochemical evaluation (excluding postpartum investigations) N = 49	
Elevated catecholamines	45
Normal catecholamines	4
Imaging (excluding postpartum investigations) N = 49	
Ultrasound only	7
MRI only	22
MRI and US	10
CT	3
n/a	6
CT and MRI	1
Timing of adrenalectomy or Paraganglioma surgery N = 50	
2nd trimester	13 total; 6 laparoscopic *vs.* 7 open
3rd trimester	5 total; 5 laparoscopic *vs.* 0 open
Simultaneously with Cesarean	6 total; 5 laparoscopic *vs.* 1 open
Within 1 month of delivery	13 total; 4 laparoscopic *vs.* 3 open vs. 6 n/a
More than 1 month post delivery	13 total; 8 laparoscopic *vs.* 1 open vs. 4 n/a

alpha blocker used during pregnancy 45.2% (14/31). Cesarean section was the most common mode of delivery of 68.3% (43/63). The timing of adrenalectomy or paraganglioma resection was evenly distributed among the second trimester, third trimester, concomitant to cesarean, 1-month post-delivery or more than 1 month post-delivery.

The timing of surgical management occurred equally during second or third trimester 36% (18/50), with adrenalectomy concomitant to cesarean section 12% (6/50) and adrenalectomy postpartum 52% (26/50). The laparoscopic *vs.* open procedure was not statistically different amongst groups. However most open procedures occurred during the second trimester (7 open procedures *vs.* 6 laparoscopic procedures during the second trimester), followed by adrenalectomy within 1 month postpar-

Table 2: Outcomes tables

Medical Complications (patients with prenatal or gestational diagnosis) N = 40	
Severe hypertension SBP > 180 or DBP > 100	6
Labile BP	3
Placental abruption	2
Heart failure and/or pulmonary edema	2
Hypoglycemia	1
Maternal death	0
Medical complications (diagnosis postpartum, after acute illness leading to emergency cesarean, maternal or fetal death) N = 23	
Cauda equina syndrome	2
Hypertensive crisis	10
Cardiogenic shock/cardiomyopathy/heart failure with pulmonary edema	7
Heart failure without pulmonary edema	1
Pulmonary edema without heart failure	2
Heart failure and/or pulmonary edema	10
Cardiopulmonary arrest	5
Disseminated intravascular coagulopathy	2
Cerebellar ischemic lesion	1
HELLP syndrome	1
Fetal complications (patients with prenatal or gestational diagnosis) N = 40	
Neonatal respiratory distress/failure	6
Fetal/neonatal death	1
Premature labor/delivery	11
Emergency cesarean section	4
Fetal complications (diagnosis postpartum, after acute illness leading to emergency cesarean, maternal or fetal death) N = 23	
Neonatal respiratory distress/failure	1
Neonatal cardiac distress	3
Fetal/neonatal death	5
Fetal outcome not reported	4
Premature labor/delivery	10
Emergency cesarean section	10
Surgical complications (patients with prenatal or gestational diagnosis) N = 40	
SVT	1
Intraoperative hypertension SBP > 200, DBP > 110, MAP > 110	9
Bleeding (adrenal vein bleed x1, inferior vena cava bleed x1, right common femoral artery bleed x1)	3
Pulmonary edema, 3L blood loss, hypoglycemia	1
Surgical complications (diagnosis postpartum, after acute illness leading to emergency cesarean, maternal or fetal death) N = 23	
Post-operative retroperitoneal bleeding reaching 10,000 L/24 hours due to left adrenal artery bleed requiring angiographic embolization	1
PEA cardiac arrest x 2 requiring ECMO	1
Cardiovascular collapse and pulmonary edema	1
V-fib arrest during cesarean section	1
Labile BPs	3

Table 3: Two-tailed Fisher's exact test

	Patients with prenatal or gestational diagnosis N = 40	*Diagnosis postpartum, after acute illness leading to emergency cesarean, maternal or fetal death N = 23*	*OR*	*95% CI*	*p*
Maternal death	0/40 (0%)	1/23 (4.3%)	n/a	n/a	0.3651
Fetal death	1/40 (2.5%)	5/23 (21.7%)	10.83	(1.18–99.59)	0.0213
Premature labor/ delivery	11/40 (27.5%)	10/23 (43.5%)	2.03	(0.69–5.96)	0.2681
Emergency C-section	4/40 (10%)	11/23 (47.8%)	8.25	(2.21–30.81)	0.0015
Maternal Heart failure or Pulmonary edema	2/40 (5%)	10/23 (43.5%)	14.62	(2.82–75.62)	0.0004

tum (3 open procedures *vs.* 4 laparoscopic procedures occurred within 1 month postpartum).

Overall maternal mortality was not statistically different in women with diagnosis during or before pregnancy 0%, compared to women with a late or postpartum diagnosis 1.6% (1/23) (p = 0.37). Premature labor was also not statistically different in women with diagnosis during or before pregnancy 27.5% (11/40), compared to 43.5% (10/23) in women with a late or postpartum diagnosis (OR 2.03, 95% CI: 0.69-5.96; p = 0.27).

Emergency cesarean section delivery was more common in women with a late or postpartum diagnosis 47.8% (11/23) compared to women with diagnosis during or before pregnancy 10% (4/40), (OR 8.3, 95% CI: 2.21 to 30.81; p<0.05). Fetal or neonatal death was more common in women with a late or postpartum diagnosis 21.7%(5/23)compared to women with diagnosis during or before pregnancy 2.5% (1/40) (OR 10.8, 95% CI: 1.18 to 99.59; p <0.05). Heart failure and/or pulmonary edema was more common among women with a late or postpartum diagnosis 43.5% (10/23) compared to women with diagnosis during or before pregnancy 5% (2/40), (OR 14.6, 95% CI: 2.82 to 75.62; p < 0.001) (Table 3).

DISCUSSION

We have described three cases of chromaffin-cell tumors detailing their presentations and management strategies. All three patients received an alpha-blocker during their third trimester, two women additionally received a beta blocker. All women underwent an uncomplicated cesarean section with two patients having delayed adrenalectomy post-partum. We additionally performed a systematic review of the most recently published case reports since 2014. We identified an increased rate of the emergency cesarean section, maternal heart failure or pulmonary edema, and fetal or neonatal death among women with a late diagnosis of a chromaffin-cell tumor in pregnancy. Our results demonstrate the importance of early diagnosis of these rare but clinically important tumors.

The results of our literature review demonstrated a maternal survival of 98% regardless of the timing of diagnosis compared with maternal mortality as high as 28.6% in a prior literature review for women with a late diagnosis.[5] A systematic review of cases performed from 1998 to 2013 identified 143 cases of chromaffin-cell cell tumors during pregnancy. Analysis of these cases demonstrated an overall maternal mortality rate of 7.3% and fetal mortality of 15.9%. Maternal mortality was 9.8% in patients with pheochromocytoma compared to the maternal mortality of 3.6% in patients with paragangliomas. The diagnosis was made during or before pregnancy in 83% of cases.[6] The difference in maternal mortality noted in our literature review is likely a result of newer technologies and improved care of the critically ill. The single maternal death in our review was a patient who presented with respiratory failure, fetal demise, and cardiac arrest as a result of ventricular fibrillation.

Maternal complications were more severe in the group of women with diagnosis postpartum, after acute illness leading to emergency cesarean, or after maternal or fetal death. In this group, there were four cardiopulmonary arrests, multiple cases of cardiogenic shock, cardiomyopathy, pulmonary edema, and multiorgan failure. The group of patients with the antenatal diagnosis had one episode of heart failure with pulmonary edema.

Medical management in pregnancy is similar to that of non-pregnant patients and includes alpha-adrenergic blockade. Phenoxybenzamine use is the most frequently cited alpha blocker used in case reports. Phenoxybenzamine use is traditionally thought of as the best intraoperative catecholamine blocker as it is a noncompetitive antagonist. A recent multi-institutional randomized controlled trial demonstrated the equal efficacy of doxazosin and phenoxybenzamine in controlling perioperative hemodynamics during surgical resection of pheochromocytoma.[7] Beta blockade or calcium channel blockers should be considered for reflexive tachycardia after initiation of the alpha blockade. Both phenoxybenzamine and doxazosin cross the placenta and rarely, have resulted in neonatal hypotension and respiratory depression related to their long half-life in the fetal circulation before delivery. Fetal-to-maternal plasma ratio of phenoxybenzamine

has been shown to be higher than doxazosin 1.6 vs. 0.8, respectively. A low percentage of doxazosin and phenoxybenzamine are excreted into breast milk, around 1% of the maternal dose.[8] All alpha blockers are pregnancy category C. Target blood pressure management have not formally been established. Goal blood pressure targets must be balanced between maternal catecholamine blockage and maintaining adequate uteroplacental perfusion.[5]

Surgical and delivery management is dependent on the stability of the mother with alpha-blockade leading up to the delivery date. In general, if a chromaffin-cell tumor is diagnosed before the 3rd trimester and appears benign on imaging, laparoscopic adrenalectomy during pregnancy should be considered. If the diagnosis occurs during the 3rd trimester, the patient should be managed medically until delivery vaginally or via cesarean section with concurrent or delayed adrenalectomy. Vaginal delivery was previously discouraged because of concerns that uterine contractions and labor would release catecholamines. However, given the lack of definitive outcome data either delivery modality may be utilized.[9-11] If peripartum adrenalectomy is planned, a multidisciplinary team should be established to coordinate delivery timing. Reasons to delay adrenalectomy postpartum include; reduced vascularity, opportunity to obtain contrast-enhanced cross-sectional imaging, as well as improved visual access to abdominal viscera. The surgical and anesthesia teams should be skilled in the anesthetic and surgical management of catecholamine-producing tumors and should be on standby before and during delivery. After delivery, the patient should be monitored closely for cardiac instability.[5] There is no formal recommendation for or against preoperative echocardiogram. However, maternal echocardiogram should be considered in patients with large pheochromocytomas or patients with late or postpartum diagnoses.

CONCLUSION

All providers who manage patients during pregnancy should consider chromaffin-cell tumors as a possible etiology for cases of gestational hypertension or atypical preeclampsia. Hypertension is the most common presenting symptom of the catecholamine-producing tumor during pregnancy.[4] Severe hypertension, labile hypertension, or hypertension before 20 weeks, without proteinuria or lower extremity edema, should raise suspicion for a chromaffin-cell tumor. After securing the diagnosis of a catecholamine-producing tumor during pregnancy, establishing a dedicated team consisting of obstetric, surgery, anesthesiology, intensive care and pediatrics at a tertiary referral hospital is critical to ensure the optimal maternal-fetal outcome.

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First Author	Date Published	Age	Timing of diagnosis (antenatal, postnatal or postmortem or after fetal demise)	Presenting Symptoms	Biochemical investigations	Imaging Investigations	Location of Lesion (unilateral adrenal, bilateral adrenal or extraadrenal)	Medical Managment	Delivery Method	Surgical Management	Surgical Complications	Medical Complications	Maternal Outcome	Fetal Outcome	Genetic Susceptibility
Group 1: Prenatal or Gestational Diagnosis															
Jose MC	2017	30	prenatal	palpitations, tremors, diaphoresis, tachycardia, hypertension, hyperglycemia	elevated urine metanephrines and normetanephrines	US	right pheochromocytoma	doxazosin and varvedilol	Full term "delivery"	laparoscopic adrenalectomy at 25 weeks gestation	Adrenalectomy complications: SVT requiring 2 doses of adenosine, hypertension	none	healthy	healthy	n/a
Wing LA	2015	28	prenatal	known diagnosis from prior preg.	elevated urine normetanephrine	none	paraganglioma	doxazosin	38 week cesarean section	n/a	none/not reported	none	healthy	healthy	SDHB
Wing LA	2015	30	prenatal (same patient as #28)	known diagnosis from prior preg.	elevated plasma normetanephrines	MRI (new left aortic lesion and lesion between superior mesenteric artery and aorta)	paraganglioma	doxazosin	32 week emergency cesarean section for bleeding	n/a	none/not reported	none	alive	(neonatal respirotary distress) discharged healthy	SDHB
Wing LA	2015	33	prenatal (same patient as #28)	known diagnosis from prior preg.	elevated normetanephrines	n/a	paraganglioma	doxazosin	38 week cesarean section	n/a	none/not reported	none	healthy	healthy	SDHB
Wing LA	2015	19	prenatal	suspected SDHB mutation	elevated normetanephrines, normal metanephrines	n/a	paraganglioma	phenoxybenzamine	cesarean section at 39 weeks	underwent resection of the paracaval lesion at time of cesarean section	none/not reported	none	healthy	fetal oversedation requring intubation discharged healthy	Suspected SDHB
Donatini G.	2018	36	(26th week gestation)	Hypertension and tachycardia	elevated urine metanephrines	MRI	Left Pheochromocytoma	alpha blockade	Vaginal (full term 39 week)	laparoscopic adrenalectomy at 27 weeks gestation	none/not reported	none	healthy	healthy	n/a
Donatini G.	2018	27	(22nd week gestation)	Hypertension and tachycardia	elevated urine metanephrines	MRI	right pheochromocytoma	phenoxybenzamine	Vaginal (full term 40 week)	laparoscopic adrenalectomy at 24th weeks gestation	none/not reported	none	healthy	healthy	negative
Donatini G.	2018	40	(10th week gestation)	Heart Failure, acute pulmonary edema and diabetes	elevated urine metanephrines and urine normetanephrines	MRI	Left Pheochromocytoma	prazosin	Vaginal (premature 37 week)	laparoscopic adrenalectomy at 17th weeks gestation	none/not reported	none	healthy	healthy	negative
Donatini G.	2018	28	(28th week gestation)	Paroxysmal Hypertension, tachycardia	elevated urine metanephrines	MRI	left pheochromocytoma	acebutolol	cesarean section at 38 weeks	open adrenalectomy 2 months post-partum	none/not reported	none	healthy	healthy	MEN2A
Donatini G.	2018	23	(27th week gestation)	tachycardia	elevated urine metanephrines	MRI	bilateral pheo	phenoxybenzamine	cesarean section at 38 weeks	Right laparoscopic adrenalectomy plus total thyroidectomy at G-week 28 THEN laparoscopic left adrenal 3 months post-partum	none/not reported	none	healthy	heathy	MEN2A
Donatini G.	2018	29	(28th week gestation)	paroxysmal hypertension and tachycardia	elevated urine metanephrines	MRI	bilateral pheo	phenoxybenzamine	cesarean section at 39 weeks	Right laparoscopic adrenalectomy at week 29 THEN laparoscopic left adrenal 5 months post-partum	none/not reported	none	healthy	healthy	MEN2A
Donatini G.	2018	28	(18th week gestation)	asymptomatic - routine fetal ultrasound demonstrated bilateral adrenal lesions	elevated urine metanephrines	Ultrasound & MRI	bilateral pheo	phenoxybenzamine	cesarean section at 38 weeks	right laparoscopic adrenalectomy at 22 weeks THEN lost to follow up	none/not reported	none	healthy	healthy	n/a (suspected SDH + family history)
Ghalandarp	2018	24	(37th week gestation)	Left flank pain, headaches, paroxysmal hypertension, gestational diabetes. NO tachycardia	elevated urine normetanephrine	Ultrasound & MRI	left pheochromocytoma	phenoxybenzamine and atenolol	cesarean section section 40 weeks	laparotomy with cesarean section section	Intra-op hypertension (240/180) after induction of anesthesia.	none	healthy	secondary apnea managed with positive pressure ventilation (healthy)	n/a
E Paula FA	2018	32	(22nd week gestation)	Sporadic episodes of headaches, diaphoresis, facial flushing	elevated urine metanephrines and urine normetanephrines	Ultrasound	right pheochromocytoma	prazosin and propranolol	cesarean section section 29 weeks	laparoscopic transperitoneal right adrenalectomy at 24 weeks gest.	Adrenalectomy Complications: Intra-op hypertension (MAP 136), tachycardia (HR 133) cesarean section Complications: none	premature rupture of membranes, placental abruption and severe bleeding.	alive	died within 48 hours of birth	n/a
Orioli L (Letter to the editor)	2017	27	(24 weeks gestation)	asymptomatic (screening due to known mutation)	elevated urine metanephrines and normetanephrines	MRI	right pheochromocytoma	prazosin and propranolol	cesarean section section 38 weeks	laparoscopic adrenalectomy wih cesarean section section	none/not reported	none	healthy	healthy	MEN2A
van der Weerd K	2017	36	11 weeks gestation	Paroxysmal spells of hypertension, palpitations, dizziness and paleness.	elevated Plasma normetanephrines	MRI	right pheochromocytoma	doxazosin preoperatively, and phentolamine (intraoperatively)	cesarean section section (38 weeks)	laparoscopic adrenalectomy at 15+6 weeks	Labile BP (SBP 110-200 mmHg).	none	healthy	healhy	negative
van der Weerd K	2017	35	11 weeks gestation	Chronic hypertension	elevated Urine metanephrines and Urine normetanephrines	MRI	right pheochromocytoma	doxazosin and metoprolol	vaginal delivery (38 weeks)	laparoscopic adrenalectomy 3 days post-delivery	Vaginal Delivery Complications: Labile BP (BP 55/33-220/130) Adrenalectomy Complications: Labile BP (SBP 70-200 mmHg)		healthy	healthy	negative
van der Weerd K	2017	18	27 weeks gestation	Labile BP (24 hour ambulatory BP 87/45 - 180/125), flushes and palpitations	elevated urinary normetanephrines	MRI	paraganglioma	phenoxybenzamine and metoprolol	elective cesarean section section (33 weeks)	Laparoscopic converted to open tumor resection at time of cesarean section section	Surgical complications: Hypertension BP 300/150 mmhg	premature	healthy	healthy	n/a
van der Weerd K	2017	37	17 weeks gestation	left hypoglossal nerve and right sided recurrent laryngeal nerve paralysis and hypertension	elevated urine normetanephrine	MRI	bilateral glomus caroticum tumors and right sided glomus vagale tumor (paraganglioma)	doxazosin and propranolol	cesarean section section at 37 weeks	Peptide receptor radiotherapy with 177-Lutetium-octreotate tx 4 tx 29.9GBq three months post-partum	none/not reported	none	healthy	healthy	n/a
Tingi E	2016	22	16 weeks gestation	asymptomatic	elevated urine metadrenaline	MRI	right pheochromocytoma	phenoxybenzamine and metoprolol	elective cesarean section section at 36 4/7	laparoscopic right adrenalectomy 6 weeks postpartum	none/not reported		healthy	Fetal acute respiratory distress syndrome and sepsis (12 days in NICU) - healthy at discharge	MEN2A

Versmissen J	2016	35	**(end of second trimester)**	hypertension	elevated serum metanephrines and serum normetanephrines	n/a	right pheochromocytoma	doxazosin and metoprolol	vaginal delivery at 38 +2	adrenalectomy 3 days post- delivery	none/not reported	none	healthy	healthy	na
Melvin A	2015	34	16 weeks gestation	postural dizziness and hypertension	elevated urinary norepinephrine, metanephrine adn normetanephrine	MRI, and Postpartum MIBG	retroperitoneal paraganglioma	"alpha and beta blockade"	elective cesarean section at 36 weeks	Open surgical resection (timing not specified)	none/none	none	healhy	healthy	negative
Dattatrya, KY	2015	25	9 weeks 2/7 - gestation	hematuria, hypertension and pallor	normal metanephrines and normatanephrines	US, MRI, cystoscopy, TURB	bladder paraganglioma	prazosin, amlodipine, atenolol	term cesarean section section	partial cystectomy during second trimester	none	none	healthy	healthy	n/a
Malinowski	2015	30	(23 6/7 weeks gestation)	excessive vomiting, chest pain and hypertension (220/110 mmHg	elevated urine epinephrine, norepinephrine, metanephrine	US and MRI	right adrenal pheo	prazosin THEN phenoxybenzamine + labetalol	emergent c-setion at 30 2/7 due to fetal distress	At 30 2/7 weeks patient underwent Endovascular aneurysm repair of a aortic pseudoaneurysm at the proximal anastomosis of a prior thoracic aortic graft. THEN cesarean section section THEN laparoscopic adrenalectomy immediately post-cesarean section section	Endovascular aneurysm repair complications: Intraoperatively labile BP with systolic BP up to 300 mmHg. Small right common femoral artery tear was repaired. Post placement fetal bradycardia forced an urgent cesarean section delivery. cesarean section: No complications, Adrenalectomy: Uncomplicated	Labile BPs during third trimester 130/80 - 160/90 at rest and 264/98 with ambulation	healthy	healthy	negative
Kiroplastis, K	2015	34	(9th week gestation)	paroxysmal hypertension (SBP 220-240 mmHg) followed by symptoms of palpitations, headache, sweating and nonspecific gastrointestinal disorder and heavy weight on right renal area..	elevated urine VMA, "catecholamines"	US and MRI	right adrenal pheo	terazosin, atenolol	vaginal delivery at 36 weeks	Posterolateral adrenalectomy at 14 weeks gestation.	Maximum intraoperative SBP 158 mmHg, minimum intraoperative SBP 100 mmHg No complications during Vaginal delivery	Labile BPs; (117/76-179/105)	healthy	healthy	n/a
Muzannara MA	2014	30	22 weeks - gestation	severe headache, hypertension (171/101 mmHg), tachycardia (HR 106)	elevated urine normetanephrine and metanephrines	US and MRI	left adrenal pheo	phenoxybenzamine	39 weeks vaginal delivery	5 weeks post partum laparoscopic left adrenalectomy and 2 weeks later uncomplicated total thyroidectomy, parathyroidectomy and central neck dissection.	Vaginal delivery uncomplicated	Hypertension prior to epidural analgesia as high as 184/110 mmHg	healthy	healthy	MEN2A
Memon MA	2014	34	13 weeks - gestation	refractory hypertension and right adrenal mass	elevated urine VMA, catecholamines	US, MRI	right adrenal pheo	phenoxybenzamine	vaginal delivery "at term"	at 13 weeks gestation admitted for open adrenalectomy	Adrenalectomy: BP as high as 180/110 mmHg	Hypertension (200/120 mmHg, sweating flushing and chest pain).	healthy	healthy	na
Kitayama, K	2015	32	12 weeks gestation	abdominal discomfort no hypertension	elevated urine metanephrines and normetanephrines	US and MRI	bilateral pheo	doxazosin	39 1 vaginal birth	15 week bilateral ex lap and bilateral adrenalectomy	no reported surgical complications or blood pressure issues	none	healthy	healthy	n/a
Mallek JT	2014	28	30 weeks gestation	back/shoulder/abdomen pain, episodic palpitations, diaphoresis, anxiety	elevated urine normetanephrines, Normal metanephrines	US, MRI	right periadrenal paraganglioma	phenoxybenzamine	36 6/7 cesarean section	Uneventful, laparoscopic adrenolectomy 5 days postpartum maximum SBP 140 mmHg	cesarean section: Mild hypotension treated with IVF,	fetal apnea, hypotension (resolved within 2 hours of delivery)	healthy	healthy	n/a
Kulkarni S	2017	22	26 weeks gestation	n/a	elevated urine VMA	US	right pheochromocytoma	prazosin, nifedipine, metoprolol	34 week cesarean section	laparoscopic adrenalectomy at time of cesarean section	Surgical: During epidural administration patient became drwosy, developed muscle fasiculations and BG 170/130, HR 120, SPO2 90% (suspected accidental lignocaine with adrenaline injection. Surgical complication rent in inferior vena cava requiring aditional 5H surgical repair then 2H tumor resection, BP fluctuations MAP 68-150, HR 80-150,, blood loss ~ 3,000mL. At end of procedure patient developed bilateral chest crepitations, pink frothy secretions through ETtube, Hgb 6 required pRBC transfusion, developed hypoglycemia,	IVC tear during cesarean section, postop pulmonary edema, hypoglycemia,	healthy	healthy	n/a
Kim J	2016	28	22 weeks gestation	headache, hypertension 173/104	elevated urine VMA, metanephrine, epinephrine, and norepinephrine	MRI	right pheochromocytoma	doxazosin	39 week vaginal delivery	25 6/7 week gestation, laparoscopic right adrenalectomy	none	none	healthy	healthy	n/a
Nerli, R	2017	27	18 weeks gestation	hypertension and proteinuria	elevated urine metanephrines	US	left pheochromocytoma	"alpha and beta blockers"	38 week "normal delivery"	18 weeks gestation laparoscopic adrenolectomy	Adrenalectomy Intraop BP as high as 200/120	Labile BPs, tachycardic episodes, palpitations	healthy	healthy	n/a
Nerli, R	2017	31	12 weeks gestation	palpitations, hypertension, diaphoreiss, syncopy	normal urine metanephrines		right pheochromocytoma	n/a	42 week "delivery"	16 week gestation open adrenalectomy and nephrectomy		none	healthy	healthy	n/a
Wing LA	2015	23	33 weeks gestation	known SDHB mutation	normal plasma metanephrines and normetanephrines	MRI	paraganglioma	doxazosin	"normal vaginal delivery"	Right carotid body and inferior vena cavo posterior to caudate lobe of liver lesions resected	resection of tumors: "hemodynamic changes"	none	healthy	healthy	SDHB
Wing LA	2015	21	14 weeks gestation	known SDHB mutation	normal normetanephrines and metanephrines, elevated plasma 3-methoxytyramine and chromogranin	MRI,	paraganglioma	none	"normal vaginal delivery"	n/a	none/not reported	none	healthy	healthy	SDHB
Wing LA	2015	17	"second trimester"	suspected SDHB mutation	elevated normetanephrines, normal plasma metanephrines	MRI,	paraganglioma	phenoxybenzamine	cesarean section delivery at 38 weeks	n/a	none/not reported	none	healthy	healthy	Suspected SDHB
Dong	2014	41	28 week gestation	hypertension, headache, dizziness, palpitation and sweating	elevated norepinephrine and epinephrines	US and MRI	Right pheochromocytoma	phenoxybenzamine	emergency cesarean section section at 32 +1 due to fetal hypoxia	simultaneous laparoscopic adrenalectomy	No intra or post op complications	none	healthy	healthy	n/a
Alvarado M	2016	38	16 3/7	diaphoresis, weakness, headaches, dizziness episodes, palpitations, NO hypertension	elevated plasma norepinephrine, normetanephrines, metanephrines. elevated urine normetanephrines, metanephrines and norepinephrines.	CT (prepregnancy)	Left pheochromocytoma	doxazosin and atenolol	cesarean section at 39 3/7	22 weeks gestation left open adrenalectomy	No intra or post op complications Specifically no hemodynamic fluctuations.	none	healthy	healthy	n/a

Shah S	2017	26	35 weeks gestation	hypertension, palpitations	elevated plasma normetanephrines, normal metanephrines, elevated urine noradrenaline	US	Right pheochromocytoma	prazosin and labetolol	cesarean section 38 weeks	6 weeks post partum laparoscopic adrenalectomy	cesarean section: No complications Adrenalectomy: uncomplicated	Post cesarean section hypertension (192/160 mmHg)	healthy	Respiratory Distres requiring 1H CPAP discharged healthy	negative
Remon-Ruiz P	2017	31	16th week gestation	Hypertensive crises (170/105 mmHg), facial pallor, shaking, headache.	elevated urine metanephrine, normetanephrine	MRI,.	right pheochromocytoma	doxazosin	cesarean section 35 weeks	Open Adrenalectomy 23rd week of pregnancy	Adrenalectomy: Converted to open due to right adrenal vein bleeding	Placental abruption	healthy	healthy	NF-1
GROUP 2: Diagnosis postpartum, after acute illness leading to emergency cesarean, maternal or fetal death															
Weingarten M (letter to the editor)	2015	24	(late third trimester) due to acute illness	severe (166/116 mmHg) and labile hypertension with headache	elevated urine metadrenalin normal non-metadrenalin	Ultrasound THEN postpartum MIBG	bilateral pheochromocytoma	labetolol prior to diagnosis and phenoxybenzamine and propranolol after biochemical diagnosis	emergency cesarean section section 48 hours after alpha blockade due to sponaneous contractions	adrenalectomy 5 months postpartum	none/none	Post operatively developed severe hypertension 240/120 mmHg	healthy	healhy	n/a
Korichi N	2014	41	29 weeks gestation (due to acute illness)	hypertension 190/120s, vaginal bleeding, headaches, dizziness, sweating, nausea	elevated urine VMA	US	left pheochromcytoma	labetalol, nifedipine, methyldopa	29 week emergency cesarean section due to vaginal bleeding and hypertensive crisis	laparoscopic adrenalectomy timing n/a	none/not reported	hypertensive crisis, placental abruption, Fetal respiratory failure/NICU	healthy	Initially intubated - discharged healthy	n/a
Liu S	2017	26	(34 weeks gestation) due to critical illness	Presenting Symptoms: acute lower extremity paralysis and urinary incontinence, history of paroxysmal hypertension during pregnancy	elevated urinary epinephrine, norepi, dopamine	CT & MRI	Metastatic Pheo (right adrenal phechromocytoma withT8,T11,T12 spinal mets)	none	Emergency cesarean section section 34 weeks	palliative radiotherapy (Dt 20Gy/5f to T7-12 and chemo (2 cycles cisplatin/etoposide) then alpha blockade then evenual spinal cord decompression	none/not reported		healthy	healthy	negative
Donatini G.	2018	23	Due to critical illness (25th week gestation)	left sided abdominal pain + T6 level paralysis @ 27 weeks developed complete T10 paralysis and cauda equina syndrome, @ 29 weeks developed brainstem bleeding hemangioma and T6 bleeding hemangioma (T6 bleeding hemangioblastoma, 4 cerebellar, 1 brainstem (bled) 1 R temporal lobe hemangiomas.)	elevated urine metanephrines, adrenaline and noradrenaline	MRI	left pheochromocytoma	labetalol	Emergency cesarean section & emergency neurosurgical procedure at 29 weeks	Left laparoscopic cortical-sparing adrenalectomy 2 months post-partum	none/not reported	Complete T-10 paralysis, cauda equina syndrome, brainstem bleeding hemangioma.	healthy	NICU (1200g) Alive	Family history of VHL
Donatini G.	2018	23	Due to critical illness (25th week gestation)	paroxysmal hypertension	elevated urine epinephrine and norepinephrine	MRI	left pheochromocytoma	nicardipine and labetalol	Emergency cesarean section at 28 weeks	Left laparscopic adrenalectomy.	none/not reported	Hypertensive crisis	healthy	Fetal Cardiac distress, died 12 days old due to cardiac failure, small bowel volvulus, meconium plug CF dianosed by F508 homozygous deletion	n/a
Donatini G.	2018	28	Due to critical illness (26 weeks gestation)	Hypertension, tachycardia, intense abdominal pain and vomiting	elevated uine metanephrines	CT Abdomen, post-partum MIBG - negative for other lesions	left pheochromocytoma	n/a	Emergency cesarean section section 28 weeks	left open adrenalectomy 1 week post-cesarean section	none/not reported	hypertensive crisis, cardiogenic shock, sysolic heart failure (EF < 20%) acute pulmonary edema, ischemic colitis, multisystem organ failure	Healthy - 1 year later	Fetal cardiac distress, polyhydramnios, acidosis.	negative
Iwase J	2017	24	after fetal demise (38 weeks gestation)	acute severe dyspnea and altered level of consciousness, hypoxia, tachycardia - no documented hypertension during pregnancy	elevated urine metanephrines, adrenaline and noradrenaline	CT	left pheochromocytoma	phentolamine	vaginal (expectant)	openleft adrenalectomy 16 h after admission prior to vaginal delivery	Adrenalectomy complications: Labile BPs (SBG 50-160 mmHg intraop). Post-operative retroperitoneal bleeding, >10,000 mL per day due to bleeding from the left adrenal artery. (angiographic embolization required on POD 4).	Hypoxic respiratory failure, pulmonary edema, cardiogenic shock, takotsubo cardiomyopathy EF 5%, renal failure.	healthy	intrauterine death	suspected MEN2A
Abdullah AE	2017	32	after fetal demise (22 weeks)	Hypertension	elevated urine normetanephrines, normal urine metanephrines	Post-partum CT, FDG PET/CT & MIBG	Organ of Zuckerkandl paraganglioma	not treated during pregnancy (post partum received nicardipine, labetalol, verapamil, prazosin)	cesarean section 15 days after premature labor began @ 22 weeks gestation	4 months postpartum surgical removal of paraganglioma	none/not reported	Uncontrolled hypertension & hypertensive crisis during diagnositic hysteroscopy 3 months post-partum	healthy	death a few minutes after birth	somatic HIF2alpha mutation
van der Weerd K	2017	35	after maternal death	Acute shortness of breath, hypertension at 28 weeks gestation	n/a	Autopsy diagnosis	right pheochromocytoma	n/a	n/a	Never occured due to patient death	none/not reported	Respiratory failure, hypertension, coma, bradycardia, v-fib arrest.	dead	dead	n/a
Dusitkasem S	2017	33	diagnosis was made "during induction of labor"	severe headache, palpitations, anxiety, abdominal pain, and hypertensive crisis (BP 200-230/100-130)	elevated urinary normetanephrines normal urine metanephrines	Post-partum CT	left para-aortic paraganglioma	labetolol (prediagnosis) single dose phenoxybenzamine prior to cesarean section section after diagnosis, phentolamine and nicardipine intraoperatively	presented at 32 weeks 5/7, seven days later induction of labor due to HTN and headache (this was aborted after results of metanephrines became available), pretreatment with with phenoxybenzamine and IVFs then emergency cesarean section section	surgical resection 2 weeks after cesarean section section	cesarean section complications: Hypertension >220/110 mmhg Paraganglioma surgery complications: Labile BP (90/40-210/130),	none	healthy	healthy	n/a

Zhou Xi	2016	33	postpartum	hypertension, vomiting and dyspnea	elevated plasma noradrenaline and adrenaline	Post-partum CT	bilateral pheochromocyto ma	phentolamine, esmolol	emergency cesarean section section at 39 weeks	bilateral adrenalectomy postpartum (timing and details unavailable)	none/not reported	POD 2 developed hypertensive crisis, hyperpyrexia, tachycardia, respiratory failure, rhabdomyalysis, renal failure, systolic heart failure (EF 25%),	healthy	n/a	na
van der Weerd K	2017	31	postpartum	Presented postpartum with persistent hypertension. Late pregnancy @ 35 weeks she developed hypertension, then headaches and palpitations.	elevated urine normetanephrines	MRI and post-partum MIBG	right pheochromocyto ma		vaginal delivery 37 weeks	laparoscopic adrenalectomy 19 days post-partum	none/not reported	none	healthy	healthy	negaive
Mita K	2016	29	postpartum	headache, nausea, hypertension.	elevated urine metanephrine	Post-partum CT and MRI and MIBG	left pheochromocyto ma	n/a	cesarean section section (37 weeks)	resection occured hospital day 70 post-cesarean section	none/not reported	Post op- hypoxic respiratory failure, hypertensive crisis, lactic acidosis, ventricular fibrillatioon cardiopulmonary arrest, disseminated intravascular coagulation, pulmonary edema,	healthy	n/a	na
van Zwet CJ	2016	27	postpartum	headaches, epigastric-retrosternal pain, palpitations, nasuea, vomiting and eye flickering (no hypertension prior to admission)	normal urine and serum metanephrines	Post-partum CT	hemorrhagic left pheochromocyto ma	IV phentolamine after cesarean section then transitioned to oral phenoxybenzami ne	emergency cesarean section section due to hypoxic respiratory failure, hypertension and tachycardia	laparoscopic adrenalectomy 22 days post cesarean section section	cesarean section complication: After induction of anesthesia she developed severe hypotension, received 10 micrograms epinephrine then developed PEA, received ACLS x 1 minute with ROSC with sinus tachycardia HR > 140, required vasopressor hemodynamic support, developed severe pulmonary edema and hypoxia as well as a second PEA cardiac arrest requiring a 10 minute resuscitation afterwhich patient was placed on ECMO, all this simultaneous with the cesarean section was being performed. Adrenalectomy without complication.	Systolic heart failure EF 20-25% due to takatsubo cardiomyopathy diagnosed. POD 7 explant of ECMO as well as MRI identifying a hemorrhagic pheochromcytoma.	healthy	Initial APGAR 0, required resuscitation x 5 min and intubation, repeat APGAR at 5 minute was 4. Infant discharged from hospital without neurological damage.	n/a
Santos D	2015	24	postpartum	hypertension (230/170 mmHg)	elevated urine and serum noradrenaline	Post-partum CT, MRI	left pheochromocyto ma	n/a	emergency cesarean section section at 33 weeks due to fetal distress	13 days after discharge from cesarean section, patient was admitted with hypertensive crisis, acute diffuse abdominal pain and underwent exploratory laparoscopic examination with no findings. However she subsuquently had a CT and then had an open adrenalectomy with histologic diagnosis of left pheochromocytoma.	none/not reported	post-operative hypertensive crisis with acute pulmonary edema,	healthy	died 14 days after delivery	n/a
Warner, KL	2015	27	postpartum	shortness of breath, vaginal spotting, nausea and vomiting, tachycardia, hypotension	elevated urine metanephrine	CT	right adrenal pheo	postpartum treated with phenoxybenzami ne adn doxazosin	emergency cesarean section 26 weeks due to fetal distress	5 weeks post partum laparoscopic right adrenalectomy without complication.	cesarean section complicated by cardiovascular collapse, and pulmonary edema.	Systolic heart failure EF 15 percent, severe hypertension (206/103 mmHg), multiple cardiac arrhythmias, bilateral pulmonary emboli.	healthy	n/a	negative
Jozwik-Plebanek K	2014	32	postpartum	postcesarean section complications (no medical issues or signs or symptoms during pregnancy)	elevated urine metanephrines, elevated plasma normetanephrines and plasma normetanephrines	Post-partum US and MRI	hemorrhagic right pheochromocyto ma	postpartum treated with doxazosin and carvedilol	38 week cesarean section	1 month post recovery, underwent uncomplicated laparoscopic adrenalectomy	cesarean section complications: Single BP spike 160/110 mmHg,	10 hours post-op headache, pulmonary edema followed by cardiac arrest, necessitating cardiopulmonary resuscitation. Takotsubo-like cardiomyopathy diagnosed EF 20%. Additionally developed dysarthria, gaze palsy, and flaccid quadriparesis due to a 20 mm ischemic lesion in R cerebellum and multiple small infarcts in frontal and parietal lobes.. Labile blood presures, headache, sweating palpitations.	healthy (6 months post-op asymptomatic including neurologically)	healthy	negative
Nerli, R	2017	23	postpartum	hypertension during pregnancy and persistant postpartum	normal urine VMA	US	right pheochromocyto ma	postpartum prazocin, metopralol	40 week vaginal delivery	2 weeks post partum	none	none	healthy	healthy	n/a
Takahashi , N	2015	29	postpartum	headache, diaphoresis, nausea, hypertension	elevated plasma dopamine, norepinephrine and epinephrine	n/a	left pheochromocyto ma	n/a	emergency 37 week cesarean section due to fetal dysfunction	post partum day 68 adrenalectomy	No complications during adrenalectomy	Postcesarean section hypoxic respiratory failure, pulmonary edema, lactic acidosis, ventricular fibrillation cardiac arrest, cardiac shock, DIC	healthy	healthy	NF-1
Daaboul Y	2015	25	postpartum	headache, vomiting, elevated liver enzymes, hypertension, Proteinuria	elevated urine VMA, metanephrines, normetanephrines	postop MRI	right pheochromocyto ma	n/a	30 week cesarean section	adrenalectomy 15 days postpartum	During cesarean section she developed ventricular fibrillation intraoperatively successfully resuscitated..	partial HELLP (hemolysis, elevated liver enzymes, and low platelets) syndrome (patient had elevated liver enzymes, proteneuria, and anemia,	healthy	healthy	n/a
Wing LA	2015	26	Postpartum	incidental mass on US prompted MRI however biopsy after labor identified PGL	elevated urine dopamine and noradrenalin	US, MRI	paraganglioma	n/a	38 week vaginal delivery	Surgical resection of presacral mass and retroperitoneal mass near right kidney removed surgically (timing unavailable)	none	none	healthy	healthy	SDHB

Gazala S	2016	28	Postpartum	labile refractory hypertension, headaches, chest tightness, nausea and vomiting	n/a	CT Chest postpartum, Echocardiogram postpartum, MIBG postpartum,	Mediastinal paraganglioma	n/a	cesarean section in "3rd trimester"	4 weeks post partum thoracotomy	Tumor deemed unresectable after 4.5H dissection. (uneventful surgery otherwise) Plan for Lutitium 177 octreotide tx and cardiopulmonary transplant	post cesarean section pulmonary edema	alive	n/a	n/a
Langton K	2017	36	Postpartum	Recurrent hypertensive crises, insulin dependent gestational diabetes,	Post-partum elevated urine normetanephrine, metanephrine, methoxytyramine, urine cortisol, and serum ACTH.	Postpartum MRI, MIBG, 68Ga DOTA-TATE PET/CT	Left Pheochromocytoma (ACTH producing)	n/a	cesarean section section 31 +5	3 months postpartum left adrenalectomy	Pre-adrenalectomy "severe facial edema and hirsutism, muscular weakness, fatigue, loss of taste, hypokalemia. No intraop complications documented	Pre-cesarean section medical: Hypertensive crisis, labile BP, (up to 200/130), at one point "uncontrollable" Postcesarean section complications: severe labile blood pressure, hyperglycemia and blurred vision.	healthy	healthy	n/a

VMA - Vanillylmandelic Acid, ACTH - Adrenocorticotropic hormone, CT - Computed Tomography, MRI - Magnetic resonance imaging, MIBG - Metaiodobenzylguanidine, US- Ultrasound

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